## ENERGY PRODUCING SYSTEMS

# BIOMASS POWER

## INTRODUCTION

Biomass can be defined as any plant or animal matter. The burning of wood is a form of biomass power and was one of the first energy forms that humans learned to manipulate. Examples of substances that can be used for biomass power are wood, crop wastes, seaweed, animal wastes, energy crops and the various components of municipal solid waste. Biomass sources can often simply be burned directly for energy production. The resulting thermal energy can be used to run machinery, drive turbines to produce electricity, or provide heat to buildings.

In some cases the organic material is first allowed to ferment and partially decompose prior to use. This process releases smaller secondary organic materials such as ethanol, methanol or methane gas. These fermentation products can then be used as a fuel source for a variety of energy systems. Methane gas can be converted to electricity using fuel cells or turbine systems, or combusted directly. Both ethanol and methanol are promising substitutes for traditional transportation fuels such as gasoline or diesel.

**CROP WASTE** Source: D. Parsons, NREL

*The majority of biomass energy sources are composed of plant material (crops, crop waste and wood) or derived from plant material (paper, cardboard and wood products). These systems are renewable sources of energy and are "re-fueled" by recurring plant growth. Fossil fuels such as coal, oil and gas were formed thousands of years ago from ancient plant and animal matter that was deposited and trapped geologically. Technically, fossil fuels are a form of biomass energy as well. However, fossil fuels represent a limited and <u>non</u>renewable energy resource. Humans began to extensively use fossil fuels only around 100 years ago and those supplies will start to be exhausted in the next 50 to 100 years. Modern biomass energy systems are based on recent plant growth cycles and are completely renewable systems. Such systems can be expected to provide energy well into the future.*

# TYPES OF BIOMASS ENERGY PRODUCTION

## FORESTRY AND AGRICULTURAL BIOMASS

More than 2 million Americans heat their homes with wood. Currently the majority (80 percent) of biomass energy generated in the United States results from burning wood and agricultural waste products. Both forests and crops provide long term sources of energy when soundly managed for re-growth. Most wood and crop waste by-products can provide on-site power to the industries that produce them. Many agricultural crop residues such as corn stalks, cornhusks, corncobs, wheat stalks, rice stalks, fruit pits and soybean stalks can also be fermented to produce liquid fuels such as ethanol and methanol. This strategy offers the dual advantage of reducing energy needs while minimizing disposal costs associated with these by-products.

Plants can be grown specifically for production of energy. Such "energy crops" are usually fast growing species that can be ready for harvest in a short time. Species such as switch grass, bamboo, fescue grass, poplar trees, willow trees, eastern cottonwood and sycamore trees are examples of common energy crops. Missouri has great potential for producing such energy crops. These crops require significantly less fertilizer than food crops, and are disease and pest resistant.


## ISSUES WITH ENERGY CROPS

*A fundamental problem associated with growing plants specifically for energy is the trade-off between food versus fuel. Increased agricultural intensities supporting energy crop production also lead to elevated fertilizer and pesticide use, soil erosion and water quality impacts. An acre of land is required to produce 40-50 gallons of bio-diesel. Many countries do not posses the agricultural resources of the United States and cannot afford to sacrifice food production to create biofuels.*

# MUNICIPAL SOLID WASTE

Paper products compose more than 30 percent of the waste sent to Missouri municipal sanitary landfills. Paper and cardboard are manufactured by processing wood pulp and represent a viable source of biomass energy. Some electrical utility companies have begun to "co-fire" these solid wastes with coal. These paper products provide a supplementary energy source and can significantly reduce air emissions as compared to utilities burning coal alone.

Source: W. Gretz, NREL

However, most solid waste generated in Missouri still ends up being placed in a municipal sanitary landfill. The average Missourian produces 4.5 pounds of solid waste every day. More than 60 percent of the material buried in Missouri landfills is composed of organic matter such as food waste, yard waste, waste paper and cardboard. While current landfills are not designed to promote the biological degradation of these products, some level of microbial fermentation of the wastes does occur. These fermentation reactions produce predominantly carbon dioxide and methane gases. The methane gas is flammable and can become a safety issue if not properly controlled. Most landfills routinely capture these gases on-site and simply burn or "flame-off" the methane.

Landfill gases are now being viewed as a potential power source. Methane gas can provide on-site power by combusting the gas to generate electrical power. Emerging technologies such as gas fired micro turbines, stirling-heat engines or fuel cells now promise to make generating on-site power from landfill gas economically favorable. Fuel cell systems have been developed that can use methane gas directly and produce electrical power with no significant air emissions.

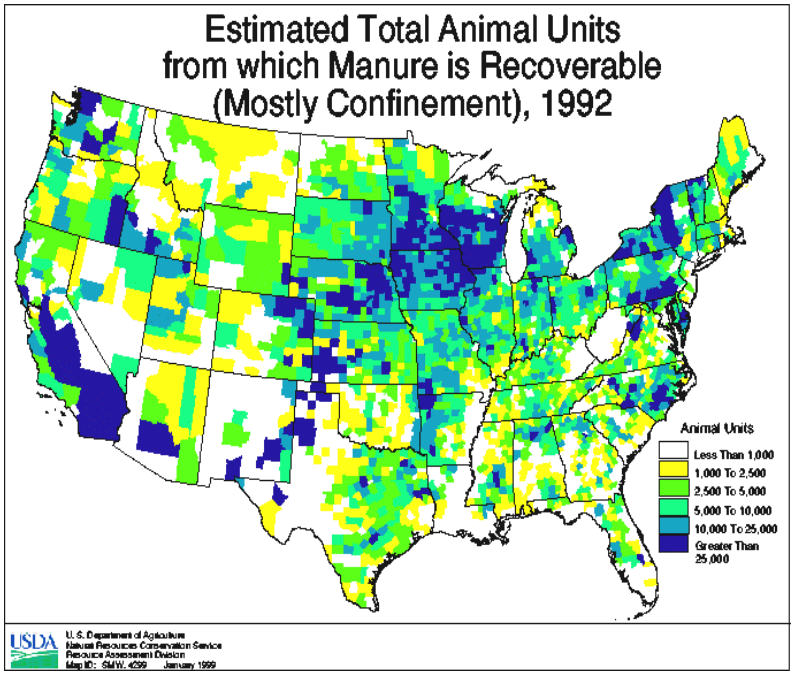
Landfill gas can also be sent off-site as a substitute for natural gas. Schools and other large buildings located near landfills can be directly connected to the land fill gas recovery system. This approach has been successfully

demonstrated at Pattonville High School in North St. Louis County, Missouri. Pattonville High has been heating its buildings with the gas produced by a nearby land fill for several years. The school estimates that they save around $30,000 a year by using land fill gas rather than natural gas for their heating needs. The U.S. Environmental Protection Agency (EPA) estimates that more than 700 land fills across the United States could be used in this manner to generate power from the land fill gas. The state of Missouri has at least 16 additional sites that could be developed to produce energy from landfill gas.

## ANIMAL WASTE POWER

Humans have used animal waste products as a fuel source for thousands of years. In many parts of rural India dried cow manure is still used as a primary fuel source for cooking and space heating needs. Such animal wastes are composed of complex organic material and as much as 60 percent of fecal matter can be composed of microbial cells mass. When produced in sufficient volume such animal wastes often pose serious environmental problems. Recently there has been a trend in the United States towards the development of *confined animal feeding operations* (CAFO's). Such facilities routinely raise thousands of animals in confined pens,

*The concentration of swine, poultry and beef operations that could be used to generate biomass energy is indicated on the following map. These are mostly confined animal feeding operations (CAFO's), which would often lend themselves to biomass power systems. As indicated on the map, Missouri has very good potential in this area. Developing these systems would not only provide local power but would also help to reduce the environmental impact associated with these highly concentrated waste streams.*



using automated feeding systems. Vast quantities of animal waste are produced from these facilities. CAFO's have come under increasing regulation as the environmental impacts of these operations unfold.

However, the waste streams produced by CAFO facilities are rich in organic matter and represent a viable source of biomass power. The waste can be sent to a digester tank where natural microbial degradation processes are optimized. The decomposing waste produces large quantities of carbon dioxide and methane. The methane can be captured and combusted to provide local heat to the operations animal pens for example. Large facilities can even use the methane produced to operate micro-turbine systems and generate electrical power. A successful operation of this type has been installed at a dairy farm in Wisconsin and currently provides enough electricity to power 250 nearby homes.

## BIOFUELS FOR TRANSPORTATION

Source: NREL

Twenty six percent of the total energy consumed in the United States is now used for transportation needs. This includes the use of personal vehicles, commercial trucking, railroads and watercraft. The current systems rely almost solely on fossil fuels such as gasoline or diesel and more than half the petroleum consumed by the United States is imported. Missouri alone consumes 400,000 barrels of petroleum a day. Missouri ranks 16$^{th}$ in the nation in the consumption of petroleum-*U.S. Department of Energy*. More than $6 billion a year are spent by Missourians on transportation fuels. Viable

substitutes for fossil fuels have been developed and are derived from plant sources (biomass). A synthetic diesel can currently be manufactured from soybeans and gasoline can be replaced with ethanol fermented from corn. If we could replace even just a portion of these petroleum-based fuels with biomass-derived alternatives, then Missouri would keep more money within the state.

Transportation fuels account for 1/3 of our nation's carbon dioxide emissions and contribute to current global warming trends. Other pollutants found in vehicle emissions such as nitrogen oxides and reactive hydrocarbons can contribute to localized air pollution (ozone). This is a real problem for large metropolitan areas and significant health risks have been attributed to these pollutants. Biomass derived fuels such as ethanol and biodiesel burn significantly cleaner than fossil fuels and can help reduce the pollution associated with using fossil fuels.

## THE FUTURE OF BIOMASS

Currently less than four percent of America's energy comes from biomass derived sources. This represents an untapped energy source when one considers the extensive agricultural resources that exist in the United States. Rapidly improving technologies such as micro-turbines, fuel cells and other small power production systems can be expected to help set the stage for smaller biopower producers. This trend will be further assisted by the deregulation of power utilities and the movement away from the big centralized power utilities of the last century.

Missouri has great potential in the area of biomass power. Currently the state generates more than 80 percent of its electricity using imported coal and spends over 30 percent of its total energy budget on imported transportation fuels. Replacing even a portion of these expenditures with "home-grown" energy sources would have a positive impact on Missouri's economy as well as help to reduce the environmental impacts associated with fossil fuels. Biomass power is a rapidly developing field and will almost certainly play a role in Missouri's future energy needs.